FIG. 1

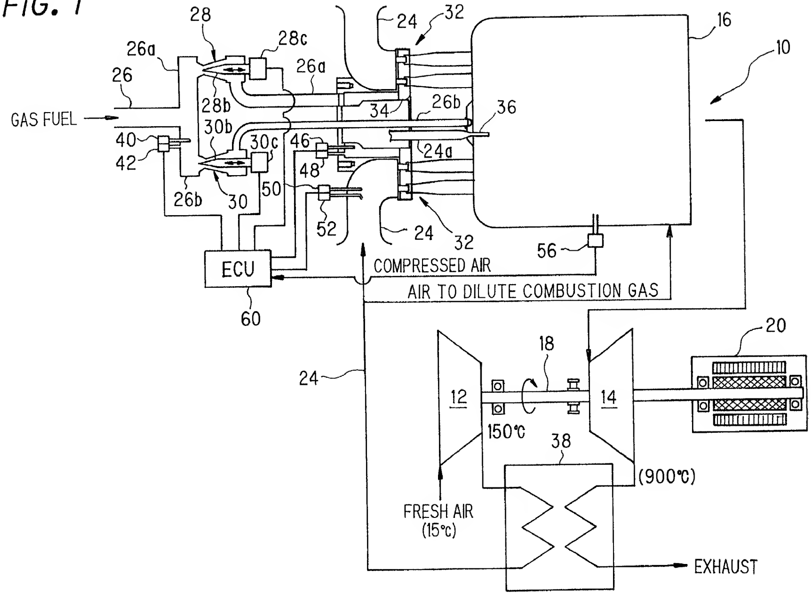

GAS FUEL
26
26a
28
28c
26a
28b
30b
30c
40
42
26b
30
46
48
50
52
ECU
60
24
32
34
26b
36
24a
24
32
16
10
56
COMPRESSED AIR
AIR TO DILUTE COMBUSTION GAS
24
12
18
14
20
150°C
38
(900°C)
FRESH AIR
(15°c)
EXHAUST

FIG. 2

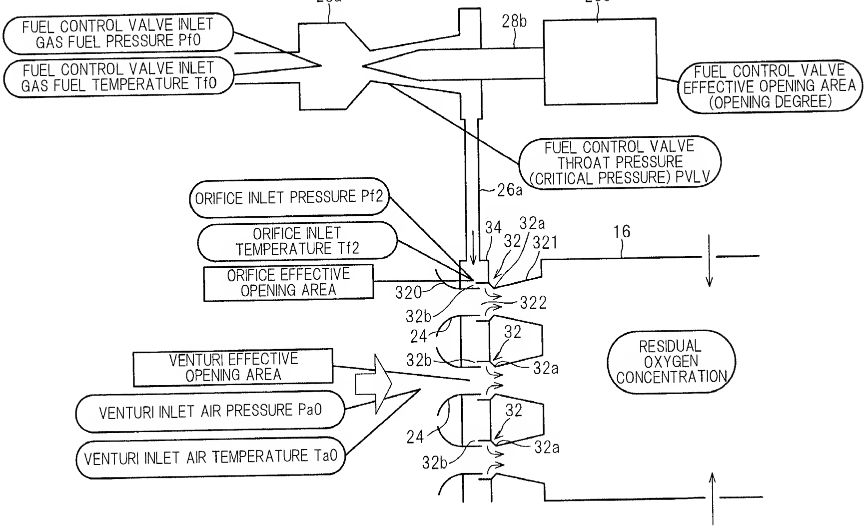

28a
28c
28b
FUEL CONTROL VALVE INLET GAS FUEL PRESSURE Pf0
FUEL CONTROL VALVE INLET GAS FUEL TEMPERATURE Tf0
FUEL CONTROL VALVE EFFECTIVE OPENING AREA (OPENING DEGREE)
FUEL CONTROL VALVE THROAT PRESSURE (CRITICAL PRESSURE) PVLV
26a
ORIFICE INLET PRESSURE Pf2
ORIFICE INLET TEMPERATURE Tf2
ORIFICE EFFECTIVE OPENING AREA
34
32a
32
321
16
320
322
32b
24
32
32b
32a
VENTURI EFFECTIVE OPENING AREA
VENTURI INLET AIR PRESSURE Pa0
VENTURI INLET AIR TEMPERATURE Ta0
32
24
32a
32b
RESIDUAL OXYGEN CONCENTRATION

FIG. 3

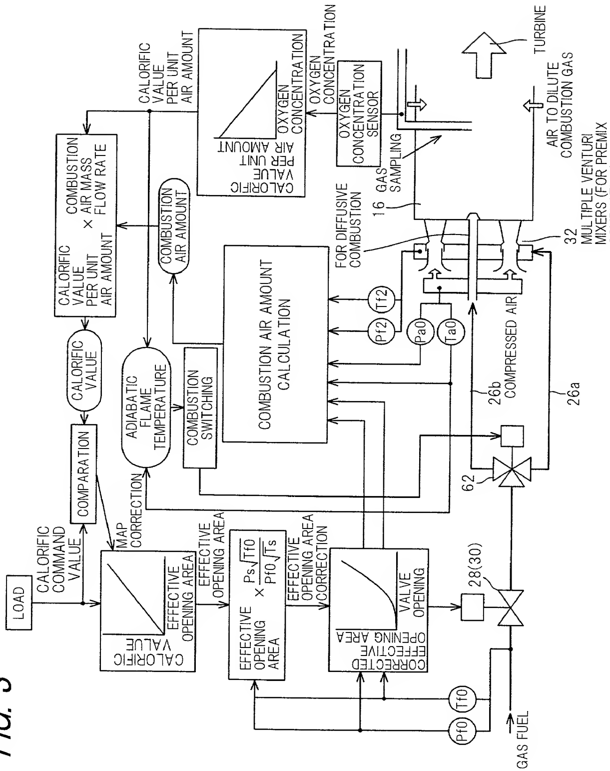

LOAD
CALORIFIC COMMAND VALUE
CALORIFIC VALUE
EFFECTIVE OPENING AREA
MAP CORRECTION
COMPARATION
CALORIFIC VALUE
CALORIFIC VALUE PER UNIT AIR AMOUNT × COMBUSTION AIR MASS FLOW RATE
CALORIFIC VALUE PER UNIT AIR AMOUNT
OXYGEN CONCENTRATION
OXYGEN CONCENTRATION
OXYGEN CONCENTRATION SENSOR
COMBUSTION AIR AMOUNT
ADIABATIC FLAME TEMPERATURE
COMBUSTION SWITCHING
COMBUSTION AIR AMOUNT CALCULATION
EFFECTIVE OPENING AREA
EFFECTIVE OPENING AREA
$\times \frac{Ps\sqrt{Tf0}}{Pf0\sqrt{Ts}}$
EFFECTIVE OPENING AREA CORRECTION
CORRECTED EFFECTIVE OPENING AREA
VALVE OPENING
Pf0
Tf0
Pf2
Tf2
Pa0
Ta0
28(30)
62
GAS FUEL
26b
COMPRESSED AIR
26a
FOR DIFFUSIVE COMBUSTION
16
GAS SAMPLING
32
MULTIPLE VENTURI MIXERS (FOR PREMIX COMBUSTION)
AIR TO DILUTE COMBUSTION GAS
TURBINE

FIG. 4

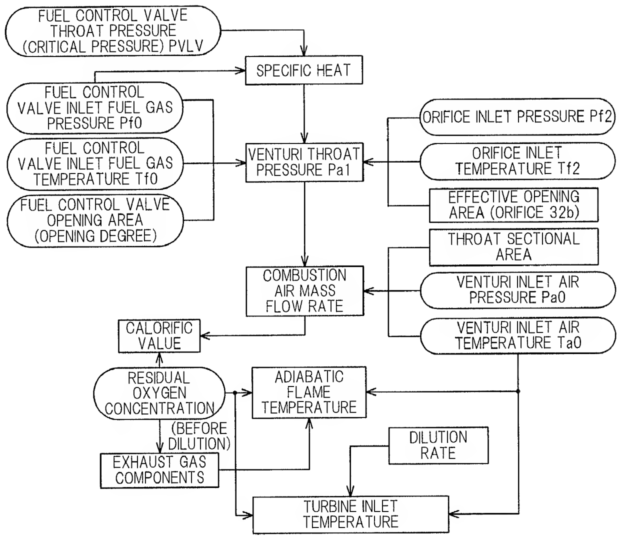

FUEL CONTROL VALVE THROAT PRESSURE (CRITICAL PRESSURE) PVLV
SPECIFIC HEAT
FUEL CONTROL VALVE INLET FUEL GAS PRESSURE Pf0
FUEL CONTROL VALVE INLET FUEL GAS TEMPERATURE Tf0
FUEL CONTROL VALVE OPENING AREA (OPENING DEGREE)
VENTURI THROAT PRESSURE Pa1
ORIFICE INLET PRESSURE Pf2
ORIFICE INLET TEMPERATURE Tf2
EFFECTIVE OPENING AREA (ORIFICE 32b)
THROAT SECTIONAL AREA
COMBUSTION AIR MASS FLOW RATE
VENTURI INLET AIR PRESSURE Pa0
VENTURI INLET AIR TEMPERATURE Ta0
CALORIFIC VALUE
RESIDUAL OXYGEN CONCENTRATION
ADIABATIC FLAME TEMPERATURE
(BEFORE DILUTION)
EXHAUST GAS COMPONENTS
DILUTION RATE
TURBINE INLET TEMPERATURE

FIG. 5

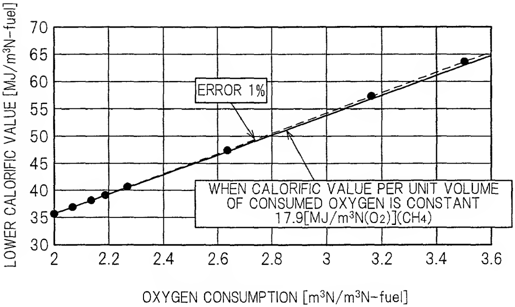

LOWER CALORIFIC VALUE [MJ/m3N-fuel]
70
65
60
55
50
45
40
35
30
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
ERROR 1%
WHEN CALORIFIC VALUE PER UNIT VOLUME OF CONSUMED OXYGEN IS CONSTANT 17.9[MJ/m3N(O2)](CH4)
OXYGEN CONSUMPTION [m3N/m3N-fuel]

FIG. 6

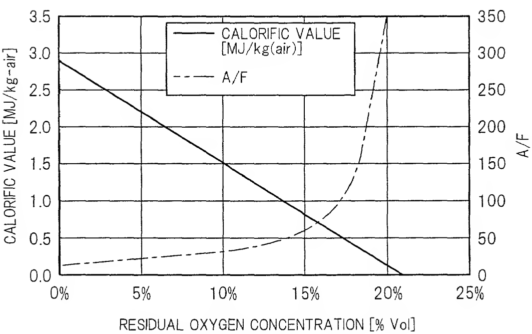
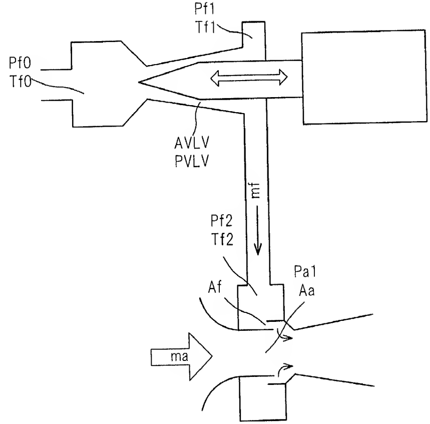

CALORIFIC VALUE [MJ/kg-air]
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
350
300
250
200
150
100
50
0
A/F
CALORIFIC VALUE [MJ/kg(air)]
A/F
0%
5%
10%
15%
20%
25%
RESIDUAL OXYGEN CONCENTRATION [% Vol]

FIG. 7

$$mf = \frac{Pf2Af}{\sqrt{RfTf2}}\sqrt{\frac{2\kappa f}{\kappa f-1}\left\{\left(\frac{Pa1}{Pf2}\right)^{\frac{2}{\kappa f}}-\left(\frac{Pa1}{Pf2}\right)^{\frac{\kappa f+1}{\kappa f}}\right\}}$$

$$ma = \frac{Pa0Aa}{\sqrt{RaTa0}}\sqrt{\frac{2\kappa a}{\kappa a-1}\left\{\left(\frac{Pa0}{Pa1}\right)^{\frac{2}{\kappa a}}-\left(\frac{Pa0}{Pa1}\right)^{\frac{\kappa a+1}{\kappa a}}\right\}}$$



Pf0 : FUEL CONTROL VALVE INLET PRESSURE [Pa]
Pf2 : ORIFICE INLET PRESSURE [Pa]
PVLV : FUEL CONTROL VALVE THROAT PRESSURE [Pa]
Pa0 : VENTURI INLET AIR PRESSURE [Pa]
Pa1 : VENTURI THROAT PRESSURE [Pa]
Tf0 : FUEL CONTROL VALVE INLET TEMPERATURE [K]
Tf2 : ORIFICE INLET TEMPERATURE [K]
Ta0 : VENTURI INLET AIR TEMPERATURE [K].

mf : FUEL MASS FLOW RATE [kg/sec]
ma : AIR MASS FLOW RATE [kg/sec]
AVLV : FUEL CONTROL VALVE EFFECTIVE OPENING AREA [m^2]
Af : ORIFICE INLET EFFECTIVE OPENING AREA [m^2]
Aa : VENTURI THROAT EFFECTIVE OPENING AREA [m^2]
Rf : FUEL GAS CONSTANT [kJ/kg K]
Ra : AIR GAS CONSTANT [kJ/kg K]
κ f : FUEL GAS SPECIFIC HEAT
κ a : AIR SPECIFIC HEAT

FIG. 8

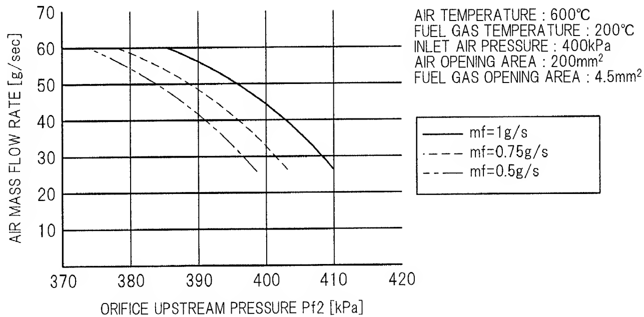

AIR TEMPERATURE : 600℃
FUEL GAS TEMPERATURE : 200℃
INLET AIR PRESSURE : 400kPa
AIR OPENING AREA : 200mm²
FUEL GAS OPENING AREA : 4.5mm²
mf=1g/s
mf=0.75g/s
mf=0.5g/s
AIR MASS FLOW RATE [g/sec]
70
60
50
40
30
20
10
370
380
390
400
410
420
ORIFICE UPSTREAM PRESSURE Pf2 [kPa]

FIG. 9

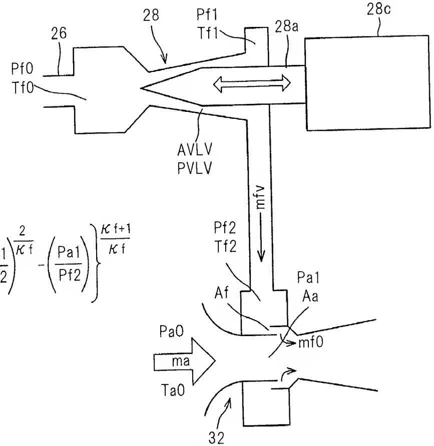
$$mfv = \frac{Pf0AVLV}{\sqrt{RTf0}} M\sqrt{\kappa f}\left(1+\frac{\kappa f-1}{2}M^2\right)^{\frac{\kappa f+1}{2(\kappa f-1)}}$$

$$mf0 = \frac{Pf2Af}{\sqrt{RTf2}}\sqrt{\frac{2\kappa f}{\kappa f-1}\left\{\left(\frac{Pa1}{Pf2}\right)^{\frac{2}{\kappa f}}-\left(\frac{Pa1}{Pf2}\right)^{\frac{\kappa f+1}{\kappa f}}\right\}}$$

SINCE VALVE IS CHOKED-FLOW RATE VALVE, MACH IS 1, THIS YIELDS FOLLOWING

$$=\left\{\frac{Pf0AVLV\sqrt{Tf2}}{\sqrt{Tf0}\ \ Pf2Af}\sqrt{\kappa f}\left(1+\frac{\kappa f-1}{2}\right)^{\frac{\kappa f+1}{2(\kappa f-1)}}\right\}^2\frac{\kappa f-1}{2\kappa f}=\left\{\left(\frac{Pa1}{Pf2}\right)^{\frac{2}{\kappa f}}-\left(\frac{Pa1}{Pf2}\right)^{\frac{\kappa f+1}{\kappa f}}\right\}$$

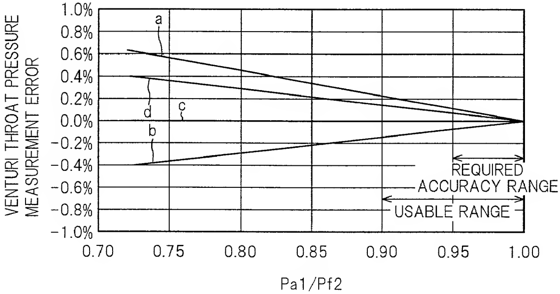
$$ma = \frac{Pa0Aa}{\sqrt{RaTa0}}\sqrt{\frac{2\kappa a}{\kappa a-1}\left\{\left(\frac{Pa0}{Pa1}\right)^{\frac{2}{\kappa a}}-\left(\frac{Pa0}{Pa1}\right)^{\frac{\kappa a+1}{\kappa a}}\right\}}$$



Pf0 : FUEL CONTROL VALVE INLET PRESSURE [Pa]
Pf2 : ORIFICE INLET PRESSURE [Pa]
PVLV : FUEL CONTROL VALVE THROAT PRESSURE [Pa]
Pa0 : VENTURI INLET AIR PRESSURE [Pa]
Pa1 : VENTURI THROAT PRESSURE [Pa]
Tf0 : FUEL CONTROL VALVE INLET TEMPERATURE [K]
Tf2 : ORIFICE INLET TEMPERATURE [K]
Ta0 : VENTURI INLET AIR TEMPERATURE [K]

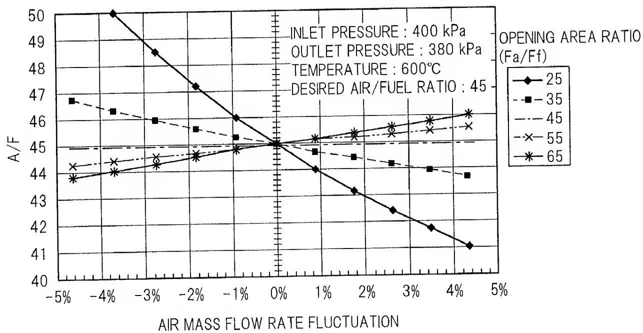
mf : FUEL MASS FLOW RATE [kg/sec]
ma : AIR MASS FLOW RATE [kg/sec]
AVLV : FUEL CONTROL VALVE EFFECTIVE OPENING AREA [m^2]
Af : ORIFICE INLET EFFECTIVE OPENING AREA [m^2]
Aa : VENTURI THROAT EFFECTIVE OPENING AREA [m^2]
Rf : FUEL GAS CONSTANT [kJ/kg K]
Ra : AIR GAS CONSTANT [kJ/kg K]
κf : FUEL GAS SPECIFIC HEAT
κa : AIR SPECIFIC HEAT

FIG. 10



SAMPLES	SPECIFIC HEAT
a	1.309
b	1.251
c	1.274
d	1.296

FIG. 11



INLET PRESSURE : 400 kPa
OUTLET PRESSURE : 380 kPa
TEMPERATURE : 600°C
DESIRED AIR/FUEL RATIO : 45
OPENING AREA RATIO (Fa/Ff)
25
35
45
55
65
A/F
50
49
48
47
46
45
44
43
42
41
40
-5%
-4%
-3%
-2%
-1%
0%
1%
2%
3%
4%
5%
AIR MASS FLOW RATE FLUCTUATION

FIG. 12

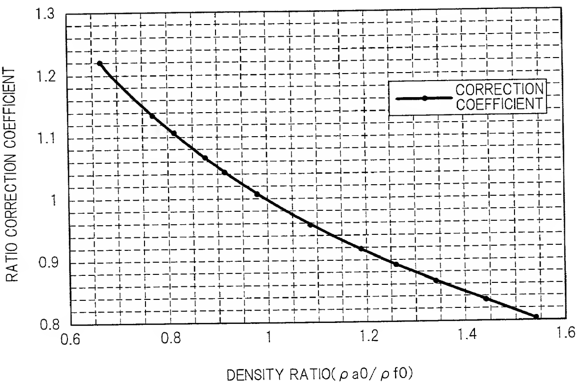
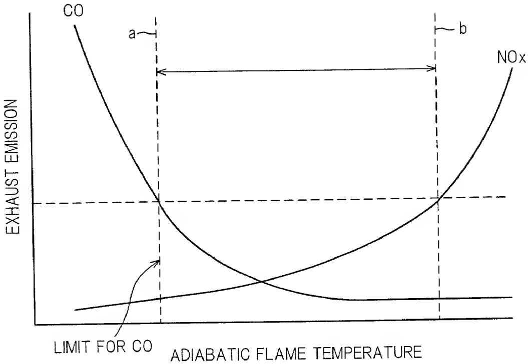

1.3
1.2
1.1
1
0.9
0.8
RATIO CORRECTION COEFFICIENT
CORRECTION COEFFICIENT
0.6
0.8
1
1.2
1.4
1.6
DENSITY RATIO(ρ a0/ρ f0)

FIG. 13


CO
a
b
NOx
EXHAUST EMISSION
LIMIT FOR CO
ADIABATIC FLAME TEMPERATURE